

**A Survey of the Parasitoid Complex Attacking Black Scale,
Saissetia oleae (Olivier), in Central and Northern California
(Hymenoptera: Chalcidoidea; Homoptera: Coccidae)**

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Abstract.—One hundred eighteen samples of the black scale, *Saissetia oleae* (Olivier), taken from a variety of host plants in 22 central and northern California counties between 1976 and 1983, yielded a total of 10,915 adult parasitoids. Among these were 9 species of primary parasitoids and 3 species of secondary parasitoids. By far the most abundant and well distributed among these were the primary parasitoids *Metaphycus helvolus* (Compere), *M. bartletti* Annecke and Mynhardt and *Scutellista cyanea* Motschulsky, all of African origin. Together, these species represented 77% of all parasitoids taken. Conversely, the primary parasitoids *Metaphycus lounsburyi* (Howard), a primary species introduced from Australia, and *Coccophagus ochraceus* Howard, an accidental introduction, were much lower in abundance and were poorly distributed. The primary parasitoids *Coccophagus lycimnia* (Walker) and *C. scutellaris* (Dalman), both considered to be cosmopolitan species, also showed low levels of abundance but both were well distributed whereas *Metaphycus luteolus* (Timberlake), a native primary, was rarely taken and showed a poor distribution. Two of the secondary parasitoids, *Cheiloneurus inimicus* Compere and *C. noxius* Compere occurred in low numbers but the former showed a good distribution whereas the latter was poorly distributed. The third secondary parasitoid, *Tetrastichus minutus* Howard, was extremely rare, occurring at only 1 collection site. *Metaphycus invisus* Compere, a recent (1979) introduction from South Africa, was recovered at colonization sites in 2 counties during the latter part of the survey. Other parasitoids of *S. oleae* introduced from South Africa during 1979-1982 did not show evidence of establishment during the later survey years but one of these, *Prococcophagus probus* Annecke and Mynhardt, was recovered at colonization sites in 1985.

As an adjunct to ongoing efforts to establish new exotic natural enemies of the black scale, *Saissetia oleae*, in central and northern California, a survey of the resident parasitoid complex in this region was initiated in 1976. Results obtained during the early stages of the survey concerning the distribution and abundance of two black scale parasitoids, *Metaphycus bartletti* Annecke and Mynhardt and *M. helvolus* (Compere), were reported earlier (Kennett, 1979). The results reported herein include data on all parasitoid species taken on *S. oleae* in central and northern California during the entire (1976-1983) survey period.

The general area of survey included a majority of the counties within the Sacramento and San Joaquin valleys (Central Valley), several coastal counties

abutting on San Francisco Bay and several other coastal-subcoastal counties extending from San Luis Obispo County in the south to Napa County in the north. Counties surveyed in addition to those previously noted (Kennett, 1979) were Sonoma, Napa, Santa Cruz and Monterey.

Various host plants of *Saissetia oleae* were examined at approximately 360 sites distributed among 22 counties. Light to heavy infestations of *S. oleae* were sampled at 118 sites. At all other sites *S. oleae* was either absent or of insufficient density to permit a sampling deemed adequate for assessment of parasitoid activity. Although olive was the most frequently sampled host plant (ca. 60% of all samples), relatively few of the samples (ca. 10%) were obtained from this host in commercial orchards. Nearly 70% of the samples were taken from urban and rural landscaping (olive, *Olea europea* L.; oleander, *Nerium oleander* L.; *Citrus* cultivars, grapefruit, orange; Modesto ash, *Fraxinus velutina* var. *glabra* Rehd.; English holly, *Ilex aquifolium* L.) and about 20% from natural stands of native shrubs (Coyote brush, *Baccharis pilularis* ssp. *consanguinea* (DC) Wolf; Toyon, *Photinia arbutifolia* Lindl.). The seasonal distribution of black scale samples (all survey years combined) was as follows: spring, 43%; summer, 16%; autumn, 29%; winter, 12%.

After sampling, the scale-infested twigs and branches were brought into the laboratory and held in glass-topped sleeve cages for 4 to 6 weeks. Issuing parasitoids were collected thrice weekly and stored in 70% ethanol for later determination.

RESULTS

Twelve species of chalcidoid parasitoids were taken on *Saissetia oleae* during the survey. Of these, nine were primary parasitoids and three were secondary parasitoids. Five of the primary parasitoids are exotic species. Among these, *Scutellista cyanea* Motschulsky, *Metaphycus helvolus*, *M. bartletti* and *M. invisus* Compere were introduced to California from South Africa whereas *M. lounsburyi* (Howard) was introduced from Australia. The initial year of introduction for each of these species was as follows: *S. cyanea*, 1901; *M. lounsburyi*, 1916; *M. helvolus*, 1937; *M. bartletti*, 1957; *M. invisus*, 1979. The remaining primaries, *Coccophagus ochraceus* Howard, *C. lycimnia* (Walker), *C. scutellaris* (Dalman) and *Metaphycus luteolus* (Timberlake), are of indeterminate origin although *C. ochraceus* is thought to be an accidental introduction from South Africa (Bartlett, 1978), and *M. luteolus* was originally described from southern California (Timberlake, 1916). Among the secondary parasitoids, *Cheiloneurus inimicus* Compere and *C. noxius* Compere were originally described from *S. oleae* taken in southern California (Compere, 1925). The other secondary, *Tetrastichus minutus* Howard, has also been taken on *S. oleae* in southern California (Smith and Compere, 1928).

Other exotic primary parasitoids of *Saissetia oleae* reported (Bartlett, 1978) as permanently established in California but which were not taken during the survey, were *Metaphycus stanleyi* Compere, *Coccophagus rusti* Compere, *C. capensis* Compere, *C. cowperi* Girault, *Diversinervus elegans* Silvestri, *Encyrtus infelix* Embelton, *Lounsburyia trifasciatus* (Compere), *Lecanobius utilis* Compere and *Moranila californica* Howard. The latter three species have been reported (Bartlett, 1978) to be extremely rare in California.

All primary parasitoids excepting *Metaphycus invisus* and *M. luteolus* were

reared from *S. oleae* taken on olive, oleander, citrus, Coyote brush and Toyon. *Metaphycus invisus*, a recent introduction, was recovered only from olive at colonization sites in Fresno and Tulare counties. *Metaphycus luteolus*, a rare species on *S. oleae*, occurred in samples from olive and oleander, principally at Sacramento Valley sites. The single samplings from Modesto ash and English holly each produced only 3 species of primary parasitoids. The secondary parasitoid, *Cheiloneurus inimicus* occurred in samples from olive and Coyote brush whereas its congener *C. noxius* was taken in samples from oleander, Coyote brush and citrus. *Tetrastichus minutus* occurred in a sample from olive at 1 site (Tehama County).

Of the 118 samples, 77 were obtained from interior valley (IV) counties and 41 were obtained from coastal and subcoastal (CSC) counties. Ninety-five percent of the CSC samples produced one or more parasitoid species whereas 75% of the IV samples were positive for parasitoids. Total parasitoid emergence for all samples combined was 10,915. Nearly 58% of these emerged from the CSC samples. Parasitoid emergence averaged 135 per sample for the CSC counties and 59 per sample for the IV counties. The average number of parasitoid species per sample for the CSC counties was nearly twice that observed for the IV counties (Fig. 1). About one-half of this difference is attributable to the relatively high number of IV samples which failed to produce adult parasitoids. Excluding those samples lacking parasitoids, the average number of species per sample was 4.2 and 3.0, respectively, for the CSC and IV counties. Approximately 51% of the CSC samples produced 5 or more species whereas about 14% of the IV samples produced 5 or more.

Ranking of parasitoids according to overall abundance, frequency of occurrence, counties of occurrence and months of occurrence showed a relatively consistent pattern among the various species (Table 1). *Metaphycus helvolus* and *M. bartletti* ranked first and second, respectively, in all categories whereas *Scutellista cyanea* and *Coccophagus lycimnia* ranked either third or fourth in all categories, with the exception that the latter species shared the second place ranking for "months of occurrence." Rankings of the remaining parasitoids were inconsistent across categories except that the 2 least abundant species, *Cheiloneurus noxius* and *Metaphycus luteolus*, ranked either last or next to last in all categories.

Grouping of parasitoid emergence data according to geographical areas, i.e., coastal-subcoastal (CSC) counties and interior valley (IV) counties, showed substantial between-area differences in parasitoid relative abundances (Fig. 2). Although *Metaphycus helvolus*, *M. bartletti* and *Scutellista cyanea* were the 3 most abundant parasitoids in both areas, their rankings differed both between areas and from the overall ranking. In the CSC area *Metaphycus helvolus* (39.7% of total emergence) outranked *Scutellista cyanea* (18.5%) and *M. bartletti* (11.7%) whereas in the IV area *M. bartletti* (40.4%) outranked *M. helvolus* (35.0%) and *S. cyanea* (11.5%). These species represented 70 and 87%, respectively, of the parasitoid emergence for the CSC and IV areas. The remaining portions of parasitoid emergence were distributed among 7 species in the CSC area and among 6 species in the IV area. Among these parasitoids, *Metaphycus lounsburyi*, *Coccophagus ochraceus* and *C. lycimnia* showed considerably higher relative abundances in the CSC area than in the IV area. With the exception of *Cheiloneurus noxius*, which was not taken in the IV area, each of the remaining parasitoids in

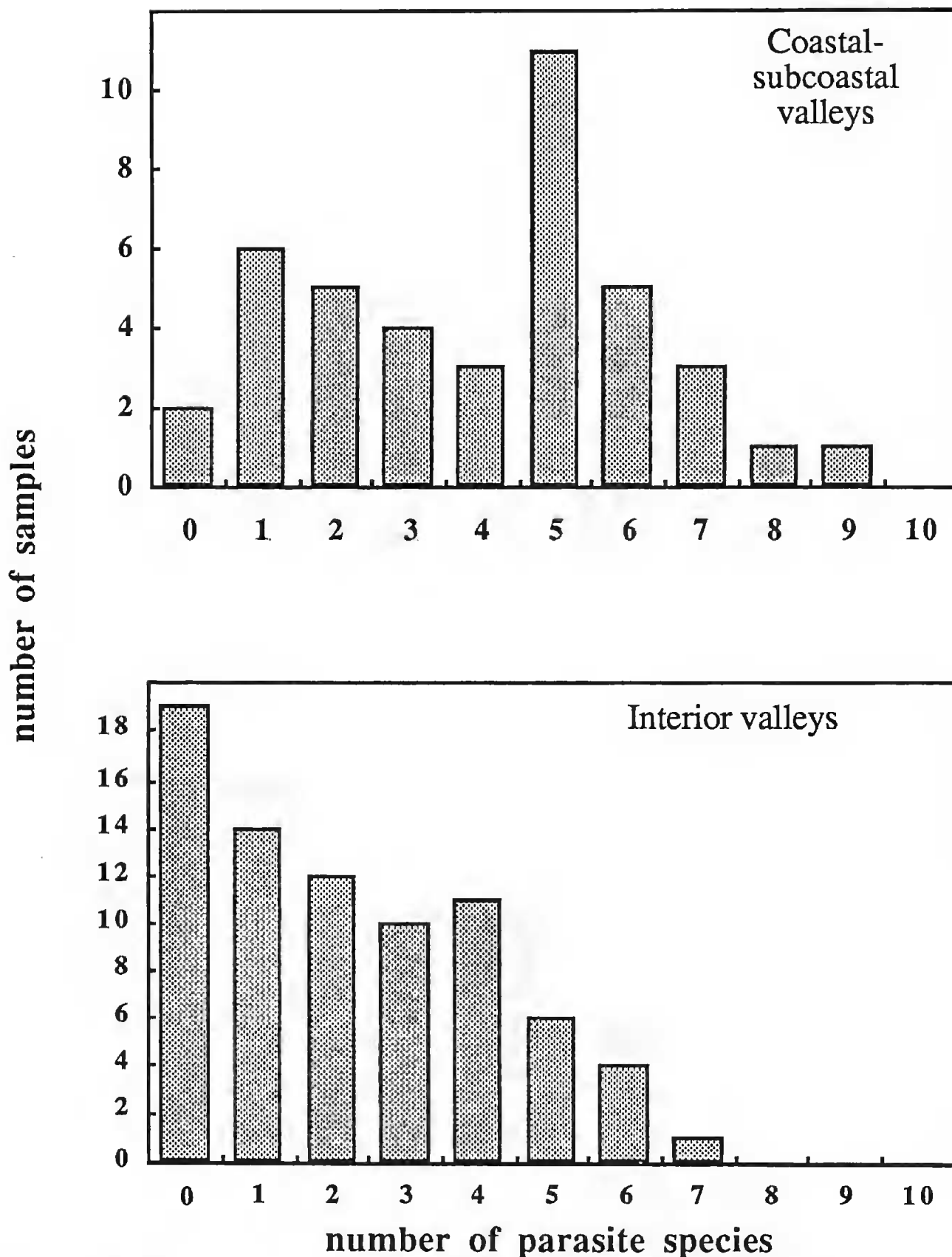


Figure 1. Frequency distributions of black scale (*Saissetia oleae*) samples according to the number of parasitoid species present at coastal-subcoastal (CSC) and interior valley (IV) collection sites in central and northern California. The mean number of parasitoid species per sample for the CSC and IV areas were 4.0 and 2.2, respectively.

this group (*Cheiloneurus inimicus*, *Coccophagus scutellaris*, *Metaphycus luteolus*) showed a similar relative abundance in both areas.

Among the introduced parasitoids, *Metaphycus helvolus*, *M. bartletti* and *Scutellista cyanea* showed good distribution and frequency of occurrence in both areas although the latter species rarely was taken in the southernmost portion of the IV area (lower San Joaquin Valley). Conversely, *Metaphycus lounsburyi* and *Coccophagus ochraceous* showed good distribution and frequency of occurrence

Table 1. Rankings of parasitoids reared from black scale samples taken in central and northern California according to relative abundance, frequency of occurrence, counties of occurrence and months of occurrence.¹

	Abundance		Frequency of occurrence		Counties of occurrence		Months of occurrence	
	Percent of total abundance	Rank	Percent of samples ²	Rank	Number ³	Rank	Number	Rank
<i>Metaphycus helvolus</i>	37.8	1	84.5	1	19	1	12	1
<i>Metaphycus bartletti</i>	23.8	2	56.7	2	17	2	11	2
<i>Scutellista cyanea</i>	15.5	3	46.4	4	15	4	10	3
<i>Coccophagus lycimnia</i>	7.5	4	53.6	3	16	3	11	2
<i>Metaphycus lounsburyi</i>	4.5	5	18.6	7	8	7	8	5
<i>Cheiloneurus inimicus</i>	4.1	6	13.4	8	10	5	6	6
<i>Coccophagus ochraceous</i>	2.8	7	23.7	6	9	6	10	3
<i>Coccophagus scutellaris</i>	2.4	8	38.1	5	15	4	9	4
<i>Cheiloneurus noxius</i>	1.3	9	8.0	9	3	9	6	6
<i>Metaphycus luteolus</i>	0.3	10	8.0	9	6	8	3	7

¹ *Metaphycus invisus*, a 1979–1980 introduction recovered at only 2 sites, and *Tetrastichus minutus*, a hyperparasitic species which was taken at 1 site, are not included in the rankings.

² Percentage of samples ($n = 97$) having 1 or more parasitoid species present.

³ Total number of counties sampled was 22.

in the CSC area but both were of extremely limited distribution in the IV area with *M. lounsburyi* occurring at a few sites near the confluence of the 2 areas (Yolo County) and *C. ochraceous* occurring at a few scattered sites in the northern half of the IV area (Sacramento Valley). Among the remaining parasitoids, *Coccophagus lycimnia* and *C. scutellaris* showed good distribution and frequency of occurrence in both areas whereas *Cheiloneurus inimicus* showed a good distribution in both areas but exhibited a poor frequency of occurrence. *Cheiloneurus noxius* showed a poor distribution in the CSC area and was absent from the IV area whereas *Metaphycus luteolus* showed a good distribution in the IV area but not in the CSC area. Both of these parasitoids showed a poor frequency of occurrence.

Among the introduced parasitoids, *Metaphycus helvolus* and *Scutellista cyanea* each appears to be adapted about equally well to both areas whereas *M. bartletti* appears less well adapted to the CSC area than to the IV area. This latter species, however, is a relatively recent introduction in California and might, in time, show greater distribution and abundance in the CSC area. *Metaphycus lounsburyi* and *Coccophagus ochraceous* appear to be poorly adapted outside the CSC area, almost to the point of exclusion. Neither of these parasitoids was taken in the San Joaquin Valley and both showed a very limited distribution in the Sacramento Valley. This near complete restriction to one climatic zone suggests that the distribution of *M. lounsburyi* and *C. ochraceous* is limited by climate. The climate of the CSC counties is highly influenced by the Pacific Ocean and is typified by narrow diurnal and limited seasonal temperature fluctuations whereas the climate of the IV counties is predominantly free of ocean influence and is typified by wider diurnal fluctuations and much greater seasonal temperature changes (Kimball and Brooks, 1959).

Among the “non-introduced parasitoids,” *Coccophagus lycimnia*, *C. scutellaris*

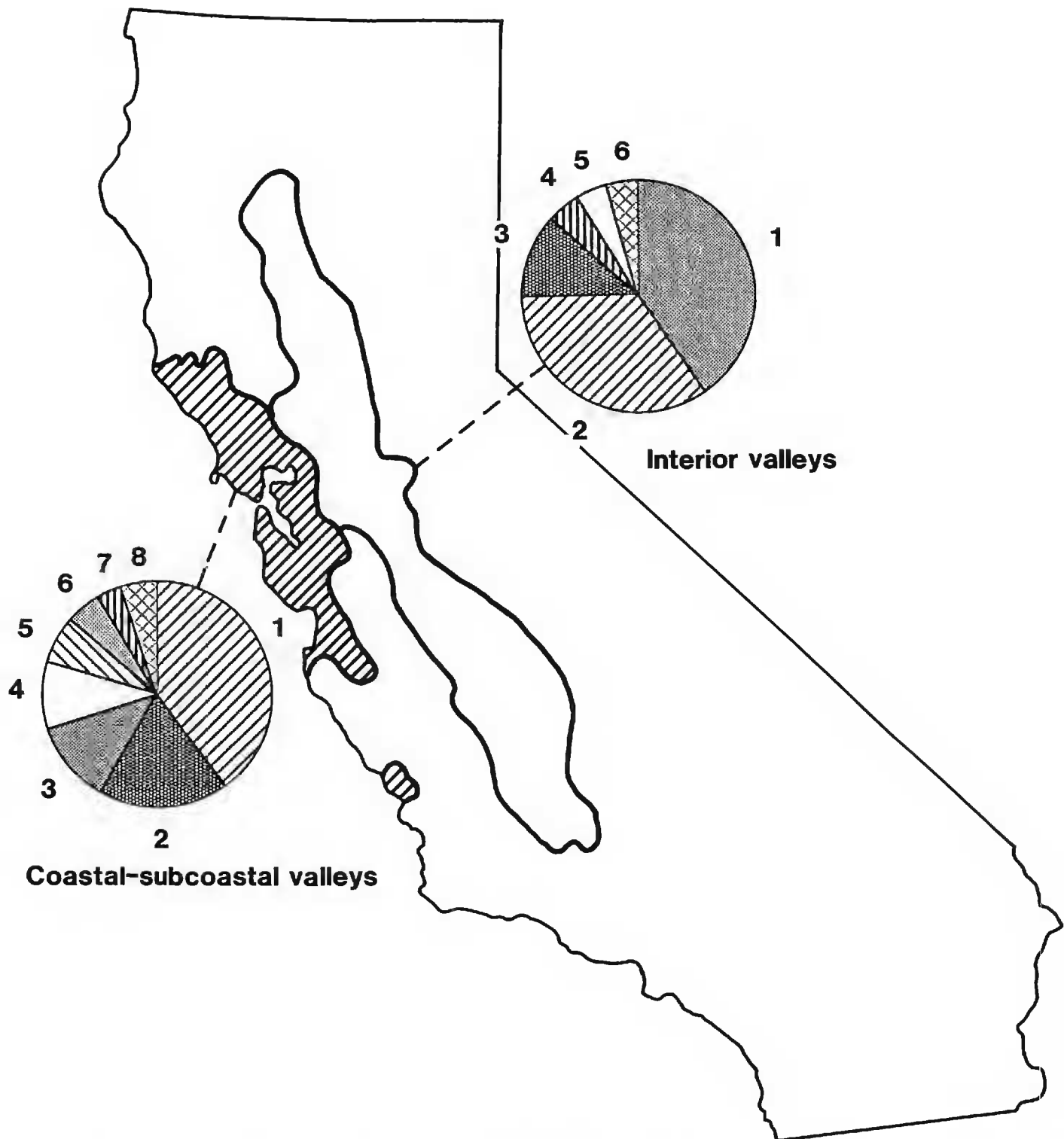


Figure 2. Relative abundances of black scale (*Saissetia oleae*) parasitoids which emerged from coastal-subcoastal (CSC) and interior valley (IV) samples taken in central and northern California. CSC area, 1 = *Metaphycus helvolus*, 2 = *Scutellista cyanea*, 3 = *Metaphycus bartletti*, 4 = *Coccophagus lycimnia*, 5 = *Metaphycus lounsburyi*, 6 = *Coccophagus ochraceus*, 7 = *Cheiloneurus inimicus*, 8 = *Coccophagus scutellaris*, *Cheiloneurus noxius* and *Metaphycus luteolus*; IV area, 1 = *M. bartletti*, 2 = *M. helvolus*, 3 = *S. cyanea*, 4 = *C. inimicus*, 5 = *C. lycimnia*, 6 = *C. scutellaris*, *M. lounsburyi*, *C. ochraceus* and *M. luteolus*.

and *Cheiloneurus inimicus* each appears equally adapted to both areas whereas *Cheiloneurus noxius* and *Metaphycus luteolus* appear adapted to only one area. Here again, the complete or near complete absence from one of the two climatic zones suggests that the distribution of these latter two parasitoids is restricted by climate.

Coincidental to the survey, several new parasitoids of South African origin were colonized on *Saissetia oleae* in central and northern California. Among these recent (1979–1982) introductions (*Metaphycus invisus*, *Prococcophagus probus*

Annecke and Mynhardt, *P. saissetia* Annecke and Mynhardt, *Aloencyrtus saissetia* (Compere) and *Coccophagus rusti*) only *M. inviscus* has shown early and continuing evidence of permanent establishment. However, the recent (1985) recovery of *P. probus* at release sites in Tehama County (K. Daane, pers. comm.) some five years after the initial colonization, suggests that this species may also have become permanently established in California.

Current efforts to add to the parasitoid complex on *Saissetia oleae* in California are concerned with the mass production and colonization of *Metaphycus zebratus* Mercet, a recent (1985) acquisition from Spain.

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